

SYSTEM FOR SUPPORTING A MULTIPLICITY OF COPY FEATURES

Background of the Invention

The present invention relates to processing of a sensed image for an output device.

Existing duplicating devices, such as for example a copy machine, a facsimile, and a scanner, include an imaging device for sensing image information (e.g., scanning or imaging) from an original document. The output of the duplicating device is stored in a file, transmitted across a network, or otherwise provided to an output device, such as a printer. Some duplicating devices include sufficient memory to store the sensed image in a compressed form or an uncompressed form. After storing the sensed image in the memory the duplicating device may provide the stored image to the output device (e.g., file, network, or printer) multiple times without having to re-sense the image. Depending upon the configuration, the system may permit simultaneous outputting (e.g., file, network, or printer) of the image and storing of the sensed image into memory. Unfortunately these systems, generally referred to as scan-once-print-many (SOPM), require significant amounts of memory to ensure that the entire image will fit within the memory. However, a sufficient amount of memory to store an entire image may be prohibitively expensive for consumer devices.

Existing duplicating devices may also include horizontal and vertical cloning capabilities, such as those disclosed in Tsuboi et al., U.S. Patent No. 5,124,799. Likewise

5 existing duplicating device may include mirror capabilities, such as those disclosed in Arai
et al., U.S. Patent No. 5,768,484. The image processing pipeline of the duplicating device
incorporates the horizontal and vertical cloning, or the mirror process, and thereafter a print
ready data stream is provided to the output device. Unfortunately, this technique requires
substantial memory and computational requirements which may be cost prohibitive for
10 consumer products.

What is desired, therefore, is a system that provides SOPM, horizontal
cloning, vertical cloning, and/or mirror functionality in a cost effective manner.

Brief Description of the Drawings

15 FIG. 1 is a block diagram of a typical copy machine image process flow.

FIG. 2 is an exemplary block diagram of a modified copy machine image
process flow in accordance with the present invention.

FIG. 3 is an exemplary block diagram of an implementation of the modified
copy machine process flow of FIG. 2.

20 FIG. 4 is an illustration of nested loops.

FIG. 5 is an exemplary pseudo code of a copy finishing scenario without a
significant memory buffer.

FIG. 6 is an exemplary pseudo code of a copy finishing scenario with a
significant memory buffer.

25 FIGS. 7A-7H is another pseudo code of a copy finishing scenario.

Detailed Description of the Preferred Embodiment

5 It is highly desirable to support a number of copy features, such as mirroring, horizontal cloning, vertical cloning, scan-once-print-many, and combinations thereof. Existing devices, such as a copy machine, scanner, computer, etc. implement each of these features in some manner, however, an efficient implementation is still desirable that reduces the necessary computational resources.

10 Referring to FIG. 1, a typical copy machine image process flow includes a scanner 10 which senses an image. After sensing an image 10 a scanner pre-processing (SPP) process 12 typically comprises functions such as compensation for non-uniform illumination, compensation for pixel-to-pixel sensitivity variations in the image sensor arrays, and spatial alignment of signals obtained from image sensor arrays (such as red, green, and blue linear CCD arrays) that are physically non-coincident. In general the SPP process 12 compensates for non-uniformities of sensing the image. Other pre-processing functions may likewise be performed, as desired. The output of the SPP process 12 is provided to an image processing pipeline (IPP) process 14 which performs image processing functions, such as color conversions, image analysis to identify areas of text, spatial filtering (sharpening of text, smoothing of screened areas), image scaling, and halftoning. In general the IPP process 14 modifies the image based upon the image itself. After processing the image by the IPP process 14, a data stream representative of an image, such as a bitonal image map for inkjet printers, is provided to a printing device 16 potentially through a printer driver. In other words, the data stream is ready for printing without further image processing. The print ready data stream may need additional "wrapping" of header and address information, as necessary. It is to be understood that the duplicating device may be any type of sensing device, such as for example, a copy machine, a facsimile, and a scanner.

5 The output of the duplicating device may be in any format, such as for example, stored in a file, transmitted across a network, a printer, or otherwise provided to an output device.

Depending upon the configuration, the system may permit simultaneous outputting (e.g., file, network, or printer) of the image and storing of the sensed image into memory.

10 The typical approach to performing mirroring, horizontal cloning, vertical cloning, and scan-once-print many (SOPM) is to include such functionality in the IPP process 14. However, performing such functionality within the IPP process 14 requires additional memory to create the modified image which may include duplicated portions of the original image, as necessary, that is thereafter provided to the printer as a data stream including the complete image.

15 Referring to FIG. 2 in contrast to the traditional approach of performing the functionality of mirroring, horizontal cloning, vertical cloning, and SOPM, within the IPP process 14, the present inventors determined that the additional functionality should be provided as an output post-processing (OPP) process 18. The OPP process 18 is an efficient technique because the image processing for these particular processes is suitable for line-by-
20 line processing on a "print ready" data stream. In contrast to the memory and computational capabilities for total image processing, line-by-line processing only requires limited memory and computational capabilities. By organization of the processes in this manner, the IPP process, which requires computational resources and time, need only be run once on each image even when providing multiple output images. The OPP process, or portions thereof,
25 may be run multiple times on the same image data provided from the IPP process. In addition, the OPP process 18 may be retrofitted with an existing IPP process 14.

One implementation of the present invention may be in form of a multi-function machine, such a combination scanner, copier, facsimile, and/or printer. Referring to FIG. 3, a multifunction machine may include a copier control processor (CPU) 20, a digital signal processor (DSP) 22. The DSP 22 performs the SPP, IPP, and OPP image computations, as necessary. The CPU 20 provides commands to the scanner 24 and hence initiates the scanning functions of the scanner 24. The CPU 20 also controls (1) the data path control 26 from the scanner 24 to the DSP engine 22 and (2) the data path control 28 from the DSP engine 22 to the printer 16. In addition, the CPU 20 may "wrap" the image data from the DSP engine 22 with header and trailer data as required by the printer 16. Also, the CPU 22 may supervise the DSP engine's 22 execution of image processing. In order to achieve these results preferably the CPU 20 and the DSP engine 22 perform coordinated actions to achieve each specific function. The coordinative communication between the CPU 20 and the DSP engine 22 is depicted as a bi-directional arrow connecting the CPU 20 and the DSP engine 22. Other communications may be bi-directional, as desired. It is to be understood that any architecture may be used to achieve the desired functionality.

In many cases the output is provided to a raster scan line device, such as a laser or inkjet printer, where the pixels are ordered from left-to-right and top-to-bottom. As such, regardless of the particular finishing features selected, the output data (typically in the form of binary CMYK separation images) are transmitted to the printer in this raster-scan order. In this context, the set of finishing features may be defined as follows. Note that for this exemplary definition the "input" and the "output" are defined with respect to the data of the OPP process.

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Mirror: This function reverses the order of the image in each output scan line. In other words, the data is provided to the printer for printing the image in a right-to-left fashion (where data is normally provided in a left-to-right fashion). This results in the image being mirrored along a vertical axis, such as for example, the central vertical axis of the image. It is to be understood that a portion of the image may be mirrored, if desired. The remainder of the image may be omitted or otherwise printed in a non-mirrored fashion.

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Horizontal This function replicates each input scan line N times left-to-right across

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Clone the output scan line (or right-to-left across the output scan line). A portion of each horizontal scan line may be duplicated, if desired. The system may ensure that the width of the output scan line is at least N times as wide as the input scan line, or otherwise sufficiently wide to print the original image and the replicated portions thereof.

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Vertical This function replicates each input image M times down the output page.

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Clone In other words, the system plays out the set of the input image scan lines multiple times in succession. Fewer than all of the scan lines may be duplicated, if desired. The system may ensure that the output page contains at least M times the number of lines as the input image, or otherwise a sufficient number of lines to include the original image and replicated portions thereof.

This function replicates or otherwise generates the final composition of the output page multiple times across multiple pages. In other words, this sends the same output page to the output device as many times as desired. Preferably, the system only needs to scan the image once or twice to provide the necessary output pages.

10 With proper ordering of the finishing features, the system is able to provide any combination of the features in a consistent and efficient manner. Referring to FIG. 4, the most natural technique for performing the desired functionality is a set of nested loops. In a preferred ordering, the outermost loop handles the number of pages to be printed, a loop within the page loop handles the vertical clones, a loop within the vertical clone loop handles the horizontal clones. The vertical clone loop preferably includes both the horizontal clone processing followed by the mirror processing.

To perform the desired functionality, the flow of control provides one or more of four different OPP modes. The modes may include (1) copy to printer (CTP), (2) copy to printer and measure encoding (CME), (3) copy to memory (CTM), and (4) print from memory (PFM).

The copy to printer (CTP) function passes the data from the DSP engine 22 to the printer 16 without modification of the image by vertical cloning. Accordingly, the output of the IPP process 14 is passed to the printer 16 with modification each line of the image itself, as necessary, to perform horizontal cloning and mirroring. If desired, mirroring and horizontal cloning may be provided by the CTP function because only limited buffering is required to perform mirroring and horizontal cloning. For example, a buffer sufficient for

5 a single output line may be used to store the resulting line of image data from horizontal cloning and mirroring.

Typically the scan lines are compressed as they are transmitted from the IPP with the OPP process 18 for the CME and CTM modes, and thereafter typically transmitted in an uncompressed format to the printer 16. The CME function is similar to the CTP
10 process, but in addition simultaneously measures the total size of the compressed form of the input image. Preferably, the input image upon which the estimated compressed size is determined is the image provided by the IPP process 14, which is likely smaller than the resulting size of a compressed image after being cloned and mirrored. During the processing
15 of the page to be printed, preferably using the CME process, the system determines if the compressed image can be stored within the available buffer.

If the compressed version of the image received from the IPP process 14 would fit within the available buffer then the system may scan the image once (another time if the first scan is not stored in memory) and then print the image from memory, including processing with the OPP process, as necessary. In this manner, multiple pages may be
20 printed by the system without having to re-scan the image multiple times. This system provides the benefit of not requiring a buffer sufficiently large to handle any potential image size, which may be cost prohibitive. If the image does not fit within the available buffer, then the copy-to-printer (CTP) process is used to print the page, which may require scanning the input image once for each output page. It is advantageous to provide the OPP processes
25 on the buffered image for the PFM process, as opposed to the resulting image after OPP processes, because the buffer requirements are less.

Due to random electronic noise in the scanning process and mechanical variations from one scan to the next, the present inventors have further determined that the compressed size of a subsequent scan may be significantly larger than the compressed size measured of a prior scan. With the realization of significant potential differences in the resulting compressed image size, the actual size of the compressed image should be sufficiently smaller than the actual buffer size, such as a fixed amount or a percentage difference. This difference in the buffer size increases the likelihood that the image may be reliably re-scanned and stored in the buffer. In other words, in order to determine whether the compressed image will fit within the available buffer based upon the prior scan, the measured size of the compressed image should be smaller than a threshold that is smaller than the available buffer.

The copy to memory (CTM) function may be used to scan an image to the buffer memory. The original document is scanned once, processed by the standard copier pipeline (SPP and IPP), and stored in the memory buffer, normally in a compressed format. Thereafter, the image data is retrieved (uncompressed if compressed) and processed by the OPP process as many times as are necessary to produce the required number of vertical clones and pages.

For use across a range of hardware architectures, the OPP process may support all finishing features both with and without a significant memory buffer. It is to be noted that without sufficient memory, true SOPM is not possible, and the OPP process degenerates to a scan-many-print many scenario.

Referring to FIG. 5 a block diagram is shown for an exemplary CTP OPP process without a memory buffer for a single page document. The preferred process

5 includes a nested structure of (a) each output page which may require re-scanning of the page, (b) each vertical clone which may require re-scanning of the page for each vertical clone, and (c) mirroring and/or horizontal cloning of each scan line. This technique is a highly efficient process for processing each page without a sufficient buffer for an entire image. It is noted that IPP refers to the image processing pipeline and likewise includes the
10 SPP process as well. Also, without a significant memory buffer the input page is re-scanned and reprocessed by the IPP for each vertical clone and for each output page.

Referring to FIG. 6 a block diagram is shown for an exemplary CTM process and PFM process with a memory buffer for a single page document. The upper portion describes the exemplary CTM process while the lower portion describes the exemplary PFM process.
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Referring to FIGS. 7A-7H is another exemplary embodiment of pseudo code cast in the tasking framework of an Oak Technology, Inc. (formerly Pixel Magic, Inc) PM44I DSP chip. The framework and its constituent primitives are described in the PM44i SDK User's Guide (Pixel Magic, Inc., September 1999). The following pseudo code
20 fragment shows in detail the flow of control and establishes that the compositions of finishing features are properly handled. Note that if OPP is in the CME state and a potential buffer overflow is detected, the state reverts to CTP and the copy is completed as a copy without memory scenario. Selectively reverting to CTP is more efficient because the additional computational cost required to continue measuring is avoided. Note also that
25 when CTM executes successfully (i.e., when the entire page has been compressed and stored in memory), OPP switches automatically to PFM and executes the playback portion of the copy with memory scenario. The active states of OPP are themselves encoded by 3 flags as

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shown in the table below, where D -> DO_DECODE; S -> DO_STORE; and E -> DO_ENCODE. An additional idle state exists which is in effect whenever an IDLE flag has the value 1. The only event that causes OPP to exit from idle state is an "activate" message from the CPU, which is only used during the playback portion of SOPM. The CPU sends this message after:

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- (1) sending any necessary trailer data to the printer for the Nth page;
 - (2) waiting for the printer to become ready to receive another page, if necessary;
 - (3) sending the header data for the (N+1)st page; and
 - (4) waiting for the printer to become ready to receive the image data for the (N+1)st page, if necessary.

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The pseudo code, the C-language "&" operator prefaces each argument of a (conceptual) function that is (conceptually) modified by execution of the function.

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It is to be understood that the present invention of processing a print ready data stream may likewise be used for applications that do not include the scanning of an image, the SPP process, or the IPP process. In this case, the print ready data stream is provided to the OPP process however obtained. Likewise, the output device may include a display, etc. In addition it is to be understood that the term image is merely intended to denote that the data is representative of a sensed document, an image map, a set of characters that may be composed, or any other representation of an output.